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FACSIMILE
AN OVERVIEW FOR THE MANAGER
STUDY REPORT
PMC 73-1

Estan Francis Imler, Jr.
Major USA

FACSIMILE

AN OVERVIEW FOR THE MANAGER

An Executive Summary
of a
Study Report
by

Estan Francis Imler, Jr.
MAJ USA

May 1973

Defense Systems Management School
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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: FACSIMILE: AN OVERVIEW FOR THE MANAGER

STUDY PROBLEM/QUESTION: To provide a brief overview of Facsimile (FAX) as background for approaching a structured analysis of, "Can FAX assist the manager in accomplishing his mission?".

STUDY REPORT ABSTRACT:

This paper is a brief overview of Facsimile (FAX) to include (1) definition and characteristics, (2) other "competing" means of communications, (3) current major uses of FAX, and (4) equipment parameters and characteristics.

With this background, a list of questions and related criteria is provided as a basis for answering the question, "Can FAX help me to more effectively accomplish my mission?".

Finally, a brief look at the future of FAX is made in terms of efforts to mitigate the major constraints that bound FAX (e.g., cost and speed of transmission).

Student, Rank Service
Estan Francis Imler, Jr., Maj., USA

Class
73-1

Date
May 1973

EXECUTIVE SUMMARY

This paper provides an overview of facsimile (FAX) to include (1) definition of FAX with major characteristics such as types of input (e.g., "graphics"); (2) a discussion of those communications systems (mail, courier, teletype, etc.) which compete with FAX; (3) those areas where FAX is currently being used (weather reporting, news photos, periodical publications, law enforcement, etc.); and (4) a breakout, in general terms, of the significant parameters of FAX as related to general "classes" of FAX equipments (e.g., resolution, speed, time, cost).

This overview provides a background basis for approaching a list of questions and related criteria designed to structure an analysis of the question, "Can FAX help me to more effectively accomplish my mission?".

The final section of the paper addresses the future of FAX in the context of ongoing efforts to mitigate constraints, such as cost and speed of transmission, which drive the FAX system. Significant work is being done in bandwidth compression and other "coding" techniques.

FACSIMILE

AN OVERVIEW FOR THE MANAGER

STUDY REPORT

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

Class 73-1

by

Estan Francis Imler, Jr.
MAJ USA

May 1973

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The author wishes to acknowledge the assistance reveived in preparing this paper:

Mr. Vern Zeigler, Defense Communications Agency (DCA), an old friend, who sits where "I once sat", and whose help and cooperation in providing access to my old files and current files in the facsimile area, were instrumental;

Mr. Harry Smith, DCA, who "rides herd" on the current facsimile research and development efforts, and who "wrote the book";

Major Lee Jackson, DSMS, who pointed the direction and allowed me to find the way; and

My wife, Verena, whose support has been almost as good as her secretarial skill, which speaks for itself.

While writing this paper the author spent considerable time in the technical areas, which, after a redirection of effort are not a significant part of this paper. Anyone interested in additional information of a specific or more technical value should contact:

DCA, Code 900
8th and South Courthouse Road
Arlington, Virginia 20305

Much of the information contained in this paper, including all of the WASHFAX section, is the result of the author's three-year tour with DCA, and specifically as the DCA Project Officer for WASHFAX during the planning, engineering, and implementation of the Phase II (switched) system.

Contents

List of Illustrations

FACSIMILE

AN OVERVIEW FOR THE MANAGER*

Introduction

In 1938, A. N. Goldsmith concluded that television was a "poor second" when compared to the future potential of facsimile broadcasting [1] . Much is known about that "loser", but what do you know about the "winner"?

The objective of this paper is to provide the manager with sufficient information on facsimile (FAX) in order that he may determine if FAX can be effectively utilized as a communications tool to assist him in accomplishing his mission.

The approach is to (1) define FAX; (2) discuss major advantages and disadvantages of FAX in light of other comparable communications means; (3) itimize and briefly discuss major uses of FAX: (4) generally discuss FAX equipments and associated characteristics; (5) consider a "working" FAX system; (6) outline a set of criteria to assist in selecting a FAX system; and finally, (7) take a quick look at the future.

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*ABSTAINER

This study represents the views, conclusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management School, nor the Department of Defense.

What is Facsimile?

There are many ways to describe FAX, depending on how general or specific one desires to be. There is, therefore, some argument when it comes to a "universal" definition. This problem does not, however, impact significantly on the considerations of this paper. With this in mind, two definitions have been selected which, together, cover most any application.

> FACSIMILE - The process, or the result of the process, by which fixed graphic material including pictures or images is scanned and the information converted into signal waves which are used either locally or remotely to produce in record form a likeness (facsimile) of the subject copy [2] .

> Facsimile is a communication process employing terminal equipment which converts graphics such as photographs or business documents into electrical signals. These signals are then converted into a reproduction of the original graphics [1] .

These definitions allude to some uses for FAX. For better understanding, it is necessary to more fully investigate the characteristics of FAX.

Graphic material or "graphics" is usually differentiated from ordinary business correspondence such as that generated or produced by the ordinary typewriter. Graphics includes photographs, drawings, diagrams, charts, illustrations and maps. FAX is usually tied closely to "graphics" because it is this capability that most clearly distinguishes FAX from other communications means.

Some other important characteristics are:

1. FAX is "error-free" in the sense that there is no chance for transposition or typographical errors.
2. FAX can overcome severe degradation during transmission, due to the fact that the human eye is the final detector of the information.
3. Using FAX, the received copy can be larger than (magnified) or smaller than (reduced) the input copy.
4. FAX does not require "skilled" operators for efficient operation.

FAX is usually constrained, in any given system, by size of copy, quality of reproduction, black and white versus color, shades of grey, speed of transmission, cost and security limitations, depending on the system requirements.

The size of copy is a factor of the mechanics of the equipment. Whole newspaper pages can be sent on those FAX equipments designed for such use, but most general-purpose FAX equipments are designed for standard letter-size pages.

The quality of reproduction depends on the resolution (sample density measured in lines per inch), the type of reproduction process, and the stability of the system.

Most FAX systems provide black and white copy. Color is becoming available for special uses.

Shades of grey capability allows for quality reproduction of photographs. "Black and white" photographs really contain "shades of grey" between the extremes of black and white. Increased logic is required for the FAX equipments to generate the additional information needed to identify some finite number of shades of grey for transmission.

Speed of transmission is a factor of the amount of information to be sent, the speed that the information becomes available for transmission and the capacity of the transmission medium (e.g., radio system, telephone circuit).

Cost is dependent upon all of the other parameters of the FAX system, and increases as size, quality, speed, and capability increase.

Security requirements can be considered as a special capability which is available at an added cost.

With this brief explanation to ensure a common basis for discussion, it is now appropriate to look at other means of communication with the associated advantages and disadvantages.

The Competition

Graphic information is obviously distributed world-wide on a daily basis. This feat is accomplished primarily through that stalwart of the communications community the Postal System. There is no question that most any graphic information can be communicated by mail. Why worry about FAX then? A closer look at the mail and some other communications systems can help answer that question.

Mail

The "mail" has been (and is) the most common method for the transmission of routine correspondence. The mail can be slow and is, in general, relatively inexpensive. Graphics may take days or weeks to arrive at it's destination depending on distance, weight, size, handling and/or the amount of maney you are willing to spend. There is also some chance that it may never arrive. Since it requires no "translation" of information, the received information is exactly what was transmitted (given that the information does arrive and is not damaged).

Classified or otherwise restricted graphic information can, with some exceptions, be sent through the mail. There is, however, a chance that the information could be compromised during the transmission process.

Courier

The idea of a courier system centers around the "hand carry" or "special handling" approach to communication. As one of the oldest modes of communication, it is inherent in many other means of communication. (Yesterday's "pony express" rider and today's rural letter carrier are "couriers".)

Most all of the correspondence within an organization and often much of that flowing between organizations is handled by couriers. The considerations that drive this means are primarily time and security. The well-organized courier system can shave days off the time required to mail the information. Local or worldwide, the time savings may be important; however, often the security provided by the courier is dominant. For many years, this was the only approved means for communicating highly classified or "sensitive" graphic information.

Video

In the extreme, video presentations such as TV pictures could be considered in the context of this paper. This requires the assumption of some means of obtaining hard copy. The cost and required quality of the graphics would be the important consideration.

Message

In discussing FAX and those means of communication which compete in the transmission of graphic information, it is important not to lose sight of the fact that most any printed information (with some exceptions for overall size and level of detail) can also be transmitted by FAX. Hence, teletype message systems (TWX or telegram) and computer-based digital message handling systems also compete with FAX.

This consideration becomes important when computing the over-all effectiveness of a FAX system, but more important, FAX has been shown to compete favorably with teletype systems for message transmission (primarily on the error-free and operator training issues) [3] .

The above information, although basic in nature, has been presented here in order to provide the perspective for discussing the advantages and disadvantages of FAX. This will be done in the next section while addressing some of the most common uses of FAX.

Current Uses

There are many specialized uses for FAX, however the largest and most important usage is in message/graphics communications. This section is laid in that context and is concerned with the advantages implicit in the fact that FAX has been chosen as the means for meeting many diversified communications requirements. General advantages and disadvantages are also addressed.

Weather

There are a number of wire and radio FAX networks which broadcast weather charts on a regular basis. Of the various nets throughout the world, the National Weather Network is the largest, covering the United States and parts of Canada. There are some 50,000 miles of telephone channels serving more than 900 receiving stations which simultaneously copy weather charts being sent from the National Meteorlogical Center in Suitland Maryland. Weather data is received at Suitland from all over the world on a regular basis. The transmission schedule is twenty-four hours a day, seven days a week. The users of this service include the Weather Bureau, Air Force, Navy, and the Airlines [2] . Pictures of the earth's cloud cover are also recorded by FAX from signals sent by the Automatic Picture Transmission satellite system [4] .

News Photographs

The rapid receipt of good quality, newsworthy photographs for timely use in newspapers and on TV is a daily requirement met by FAX.

Both color and black and white photographs are sent world-wide by wire and radio FAX nets. The Associated Press and United Press International are the largest users in the United States [4] .

Periodical Publishing

Large format photographic FAX recorders are being used in the publishing industry to retain original format and error-free transmission. For instance, "The Wall Street Journal" transmits whole-page negatives which can then be transferred to plates used on their rotary printing presses. Hence, the east coast layout can be transmitted to the west coast where it is again printed, thereby precluding the shipment of newspapers across the country [4] .

The Japenese are also using FAX for printing newspapers. The thousands of ideographs contained on a single sheet of newspaper make FAX an ideal means of transmission [2] .

Law Enforcement

FAX in law enforcement is primarily a tool for suspect identification. Fingerprint cards can be sent

to a centralized fingerprint file for comparison. When identified, the suspect's record can then be transmitted to the originator of the request [4].

Storage and Retrieval

Once the FAX system converts the graphic information into some form suitable for electrical transmission, it is then possible to digitize the information. That information can then be placed in computer storage, and upon request, it can be reconverted and printed on a FAX output device. Hence, printed matter in any format with pictures, diagrams, maps, etc., can be stored and retrieved intact [2].

General

Thus far, this paper has defined FAX, discussed those communication systems that might logically be considered as competing with FAX, and looked at some of the most common uses of FAX. In this setting, it is hoped that some of the advantages of FAX have become apparent. For the sake of conciseness, however, advantages (and disadvantages) are listed below.

Compared to the mail:

FAX is much faster (measured in minutes or fractions thereof).

FAX is more expensive (differences in cost is relative to the specific application).

Compared to a courier system:

FAX is faster.

FAX is more or less expensive, depending on the specific application.

Compared to a message transmission system:

FAX is comparable in speed in some cases and slower in others.

FAX does not require skilled operators (as opposed to computer or teletype operators).

FAX is error-free.

FAX has proven itself more cost-effective in some applications.

It can be clearly seen that advantages and disadvantages are difficult to define without completely defining the specific systems to be compared. Each FAX system is different, based on the requirement equipments, priorities, configuration, and environment. Hence, it is difficult to generalize.

Equipments

The backbone of the FAX system is the terminal equipments. The requirement (mission) drives the selection of equipments and the associated communication link. The most common parameters to be considered in differentiating among FAX equipment are overall system cost, speed, output quality and copy size.

FAX equipments will be discussed here without reference to specific manufacturer; however, a representative list of major firms in the FAX field is included as Appendix A.

The requirement can be stated in terms of time, cost, speed, quality; or combination thereof, with other parameters such as security and the capability of receiving copy at an unattended terminal also considered.

As mentioned previously, quality is a factor of the resolution measured in lines per inch. The higher the resolution, the better the quality (and the larger the amount of information to be transmitted per square inch of copy).

Let us assume that a requirement exists for transmitting handwritten notes, pages extracted from technical publications (to include drawings and charts, but no photographs), and normal typewritten correspondence. This requirement fits the most common FAX category; and hence,

there is a large selection of equipment available to meet this requirement.

Figure 1 shows a generalized breakout of FAX equipment parameters. The resolution range of 75-100 lines per inch is consistent with the assumed requirement.

Speed is measured in lines per minute and depends primarily on the bandwidth of the communications link. (The wider the bandwidth the greater the speed and the higher the cost.)

The time to transmit in minutes per page is directly related to the speed, although there are variations due to the mechanical "handling times" of the different equipments.

The costs shown are representative ranges. The fact that some relatively more "efficient" equipments appear to cost less is due to the emphasis by different manufacturers in different areas of the market. Hence, a given firm may only produce equipments to operate at 540 lines/minute.

Figure 1

FAX Parameters

Resolution Lines/Inch	Lines/Min	Min/Page	Cost Lease/Mo	Cost Buy
75-100	100-200	6-15	250-700	10K-16K
75-100	201-300	2.8-6.3	150-700	5.5K-16K
75-100	301-500	2-3	150-750	5.5K-16K
75-100	501-1000	1-1.15	140-700	6K-16K

The identical costs limits shown occur because the same equipment may be built to operate at several different speeds simply by setting a switch.

Equipments and transmission paths exist whereby speeds of up to 18,200 lines per minute can be transmitted. This equates to approximately ten seconds per page, or six pages per minute. The equipments have resolutions of between 100-200 lines per inch and the equipment costs run $1200 per month (lease) and in excess of $50,000 to purchase. All the costs in this section are for one complete terminal which may be a recorder (receiver) and scanner (transmitter) combined, or two separate pieces of equipment. Hence, costs must be doubled for each two-way link.

WASHFAX

The Washington Area Secure High-Speed Facsimile (WASHFAX) Net is not a typical FAX system; however, it is a relatively sophisticated network and provides an excellent vehicle for discussion.

Old Network

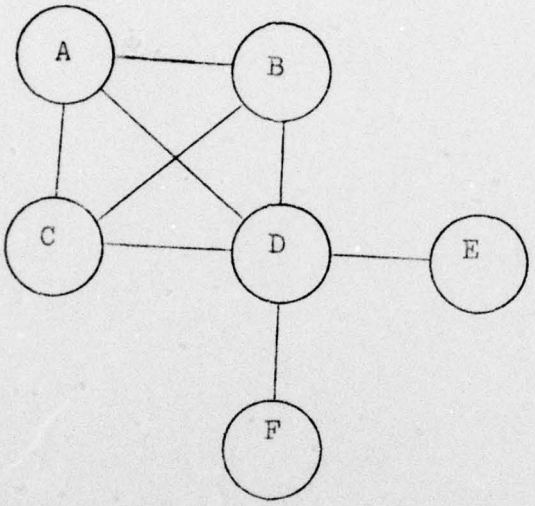
WASHFAX is a cryptographically secured (approved for transmission of SECRET information), high-speed FAX net interconnecting high-level subscribers in the Washington, D. C., area. (The subscriber list is classified CONFIDENTIAL).

Figure 2 depicts WASHFAX in its original "dedicated" configuration. Xerox Corporation LDX (Long Distance Xerography) terminals were utilized on a one for one basis for each circuit. That is, there were five LDX terminals at Site "D", each permanently tied into one of the five circuits radiating to the other five sites. The communication circuits were special wide bandwidth (240 KHz) links; very expensive but providing high page throughput (six pages per minute).

The WASHFAX was deemed a "necessity" by the subscribers notwithstanding the fact that the system was so expensive that it could not possibly be justified based on the usage factors (e.g., total pages per day). Rather, the system was justified on an emergency (contingency) use basis.

Figure 2

WASHFAX (Dedicated)



It was determined that an emergency that could require the rapid transfer of the graphic information from one user location to another, could very easily be the type of emergency that would preclude putting a courier on the streets of Washington, D. C.. This did not, however, completely explain the high-speed factor, to which most of the high cost was attributed. Much close liaison with the users finally disclosed that they "liked" the system to such a degree that it would have been cheap at <u>twice</u> the cost.

New Network

Now that you have seen the old (dedicated) system, the new switched system (Figure 3) is a logical improved version.

It can be seen from the figure that the network now revolves around a switchboard at Site B. The idea of a switch stemmed from a desire to increase the number of users in the net. Under the old (dedicated) system concept a new piece of terminal equipment was required at each site wishing to tie into a new subscriber. In addition, half the cost of a very expensive new communication link also had to be paid for. Hence, the advantage of a switched system becomes very clear.

Figure 3

WASHFAX (Switched)

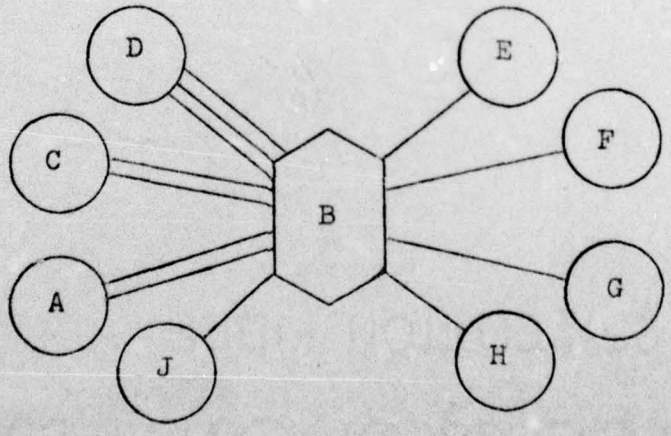


Figure 3 does, in fact, show some new subscribers; however, the number of LDX terminal equipments remains about the same. This is possible since Site D, for instance, now has three LDX terminals, vice the five terminals previously.

A disadvantage to the switched system is that a user can be "busy". (This could not happen in the dedicated system.) This has not been a significant problem in the WASHFAX; however, a "priority" system could be implemented if some future need required it (based on additional subscribers). This might be no more than a telephone call from the user at the top of the "pecking order" saying, "You will discontinue your current transmission and accept mine".

Criteria

Recognizing that the overview approach of this paper necessarily precludes an in depth analysis of FAX and the associated parameters; it is, therefore, desirable that some means of structuring an analysis of the question, "Can FAX help me to more effectively accomplish my mission?", be defined. Appendix B is a list of questions and related criteria aimed at answering the above question.

In applying this technique it should be remembered that the analysis does not provide an answer. The decision is still subjective and rightfully left up to the manager (decision maker).

The final section of this paper looks to the future through the on-going efforts to investigate the major constraints inherent in the FAX system.

The Future

If there is one factor that inhibits the use of FAX, it is, of course, cost. This is not a new situation. It is only more critical now that money is tight. What is not necessarily apparent, though, is the "vicious circle" surrounding FAX.

There are three interdependent parameters to consider: cost, quality, and speed. Quality connotes high resolution or grey scale which equates to much information to be transmitted. Now, if the information can be sent slowly, then the cost is relatively low and primarily involved in the hardware. If, however, speed is a significant factor, then the transmission link becomes the problem, due to the requirements to move large amounts of information in a short period of time. This requires a large, and hence expensive, communications "pipe". It should be clear that the only way to minimize cost is to minimize quality and speed. Or to look at it another way, for a given cost you have to trade off quality and speed. (You cannot increase one without decreasing the other). There is some hope, however, that work currently being done in the areas of bandwidth compression and redundancy reduction will realize increased improvements beyond those already realized [5] [6] [7] .

Bandwidth compression is a general term for any technique whereby information is "coded" such that less than the full amount of information can be transmitted and still be able to reconstitute all the information on the other end. A simple example might be the use of abbreviations, where two letters, for instance, MO, can be transmitted and be understood to mean Missouri. Using highly sophisticated techniques adaptable to FAX, it is currently possible to achieve a 6:1 reduction for general application, and still higher reduction ratios for specific requirements. This means that a complicated drawing which normally takes six minutes to transmit over a given bandwidth circuit, will take only one minute (on the average) using bandwidth compression techniques.

Another technique for increasing the amount of information that can be transmitted over a given bandwidth circuit is the use of modems (modulator-demodulators). A modem is capable of somehow compartmentalizing some factor such that the transmission circuit is more efficiently utilized. Time and frequency are examples of factors used. Modems can be used in conjunction with bandwidth compression techniques to gain added reductions. Hence, if the cost of modems and of bandwidth compression logic is kept below the incremental cost for the transmission circuit required to obtain the same transmission rate, then overall costs

will be reduced. Currently, in many cases, the money saved on reduced circuit costs, more than pays for the additional equipments.

Thus, we have quickly covered FAX. It is the feeling of the author that the perspective gained by the overview is far more valuable to the average manager than dwelling on a few specifics without that perspective.

FAX is here to stay. "Get a handle on it" and it can help you solve your management problems.

Appendix A

Facsimile Manufactures

This list is representative of major business firms in the facsimile area.

Alden Electronic and Impulse Recording Equipment Company
Washington Street; Westboro, Massachusetts 01581

A. B. Dick
5700 W. Tonly Avenue; Chicago, Illinois 60648

Electronic Image Systems, Incorporated

LitCom Division of Litton Industries
1770 Walt Whitman Road; Melville, New York 11746

Magnavox System, Incorporated
270 Park Avenue; New York, New York 10017

Muirhead Instruments, Incorporated
1101 Bristol Road; Mountainside, New Jersey 07092

Stewart-Warner Electronics
1300 N. Kostner Avenue; Chicago, Illinois 60651

Telautograph Corporation
8700 Belanca Avenue; Los Angeles, California 90045

Western Union

Xerox Corporation

Appendix B

Criteria

Question	Criteria
1. Do I have a requirement?	Graphics Message Both
2. How important is the requirement?	Critical Routine
3. What volume of input is involved?	High Low
4. What type of requirement is it?	New Replace Backup
5. What is the quality required?	Photographs Fine detail Typewritten Handwritten
6. What is the speed required?	Fast (.15 min/page) Medium (1 min/page) Slow (6 min/page)
7. What is the configuration required?	Dedicated Switched
8. What is the security classification required?	Secret Confidential Unclassified
9. What are the special requirements?	Color Grey scale Size

Your answers to the above questions can all be related to system cost. In general, the costs increase directly as system performance increases. The following ideas are to help guide your analysis:

A critical requirement may justify a high cost, whereas a routine requirement might not.

A new requirement could also justify a high cost, whereas a replacement or backup requirement would probably not.

A critical requirement may not necessarily justify transmission at fast speed.

A routine requirement probably cannot justify transmission at fast speed.

With a better feel for the parameters of the problem you are now prepared to talk to your communications personnel about some specific equipments to fulfill your requirement.

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An excellent overview of state-of-the-art, developments in the fields of television, facsimile and optical character recognition.

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Discussion of Army tests (USASTRATCOM) comparing facsimile with teletype.

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An unpublished "handout".

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Recent advances in digital computer and optical technology have made image spectra determinations possible. A rigorous look at treating pictures adaptively on a piecewise basis to obtain bandwidth compression using Fourier transform.

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Three methods of redundancy reduction are addressed for bandwidth compression of facsimile and slow scan TV.